ATHIC 2014 @ Osaka University

Study of Performance for Particle Identification at sPHENIX

Kazuya Nagashima

for the PHENIX collaboration

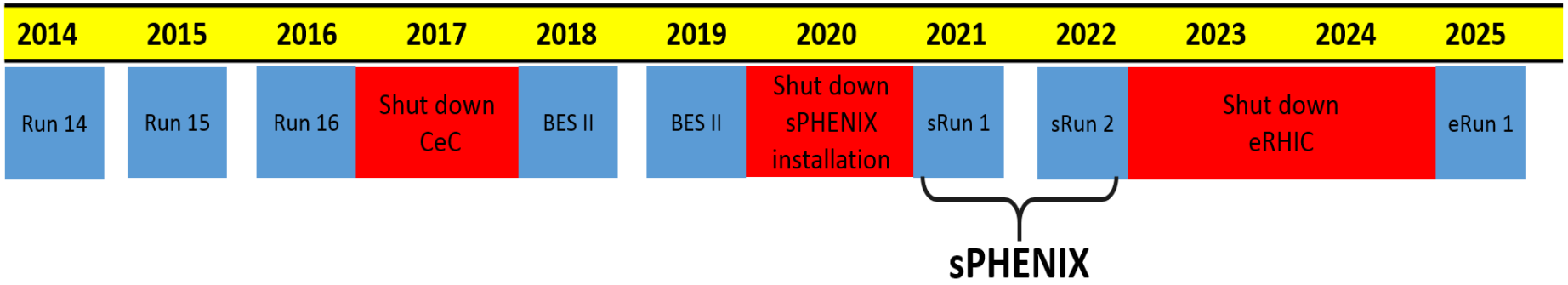
Hiroshima University

✓ Outline

- sPHENIX
  - schedule
  - Physics motivation
- Electron identification
  - calculate electron efficiency and pion rejection
- Optional Preshower detector
  - Physics motivation
- Optimization shape of the preshower cell
- Summary

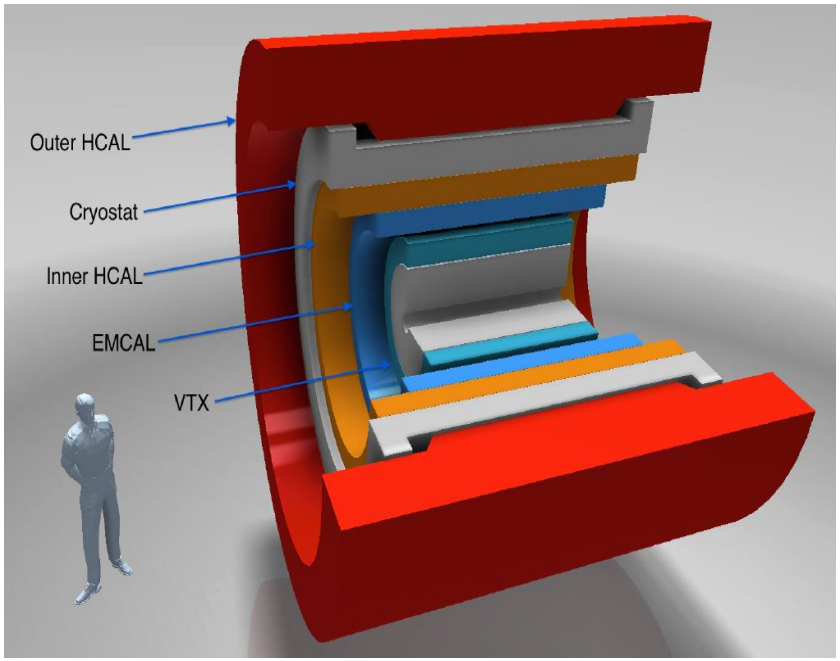
✓ sPHENIX

BNL schedule



Upgrade points from PHENIX

- Larger acceptance and Fast readout
  ($\varphi = 2\pi$, $|\eta| < 1$)
- Additional tracking
  for measurement of Upsilon
- EMCal and HCal
  for measurement of Jets
- (Optional Preshower detector for PID)



✓Physics motivation

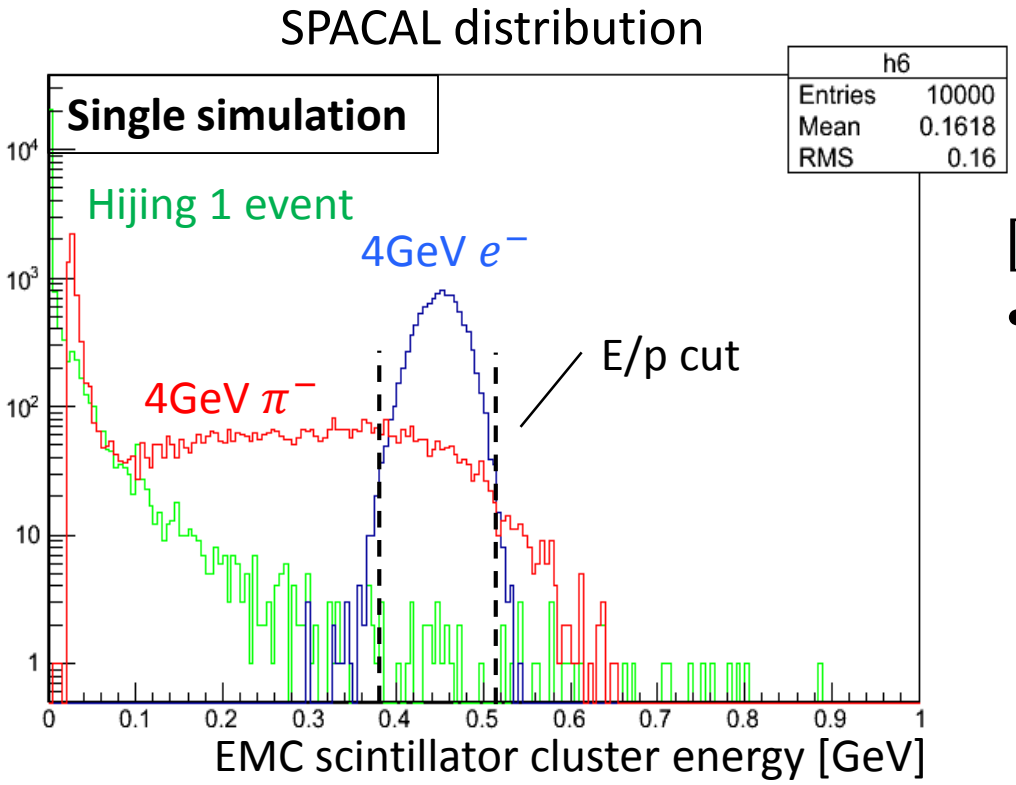
- QGP screening study by measuring upsilon states etc.
- Jet quenching study via full (tagged) jet reconstruction.
- Jet fragmentation function modification.
- Nuclear suppression of π^0 yields up to p_T = 40GeV/c
- γ-jet correlation

- Detailed physics motivation
  - K.Shigaki, 8/08 morning
    「Next stages of PHENIX for enhanced Physics with Jets, Quarkonia, and Photons」

✓ Electron identification with E/p cut

「Simulation」

- Generate 4GeV e^- and π^-,
- Magnetic field off,
- With Hijing background (AuAu 10%C in B-off)



[single event]

- E/p cut

(electron mean energy ± 15%)

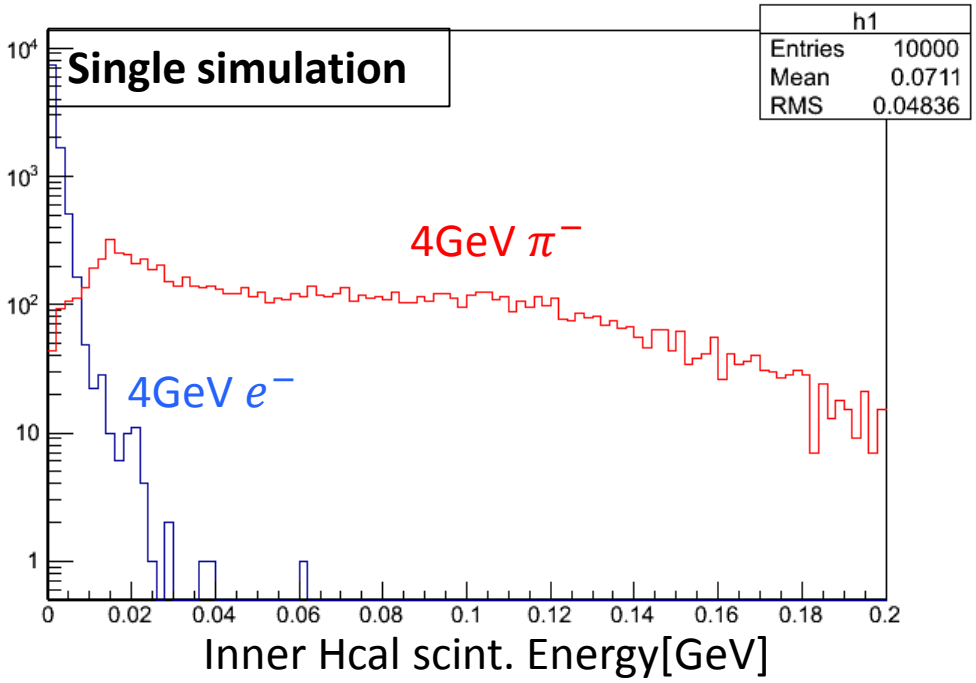
- electron efficiency of 0.99
- pion efficiency of 0.12
- pion rejection of 8.0

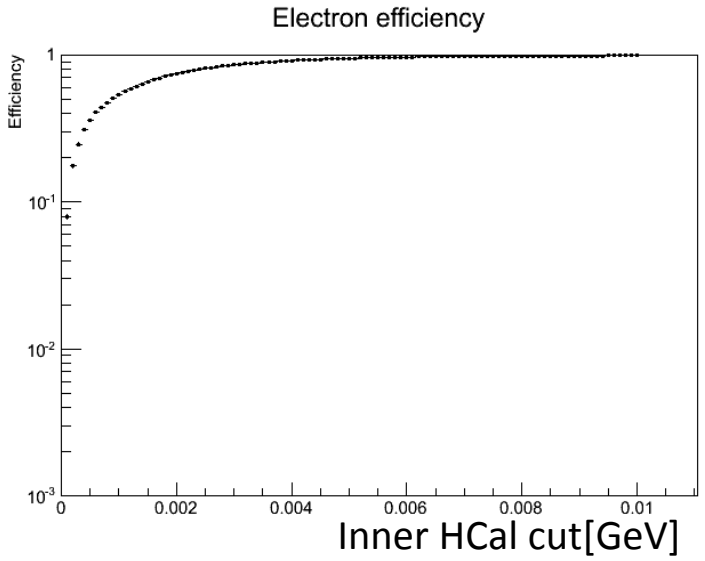
✓ Electron identification with HCal

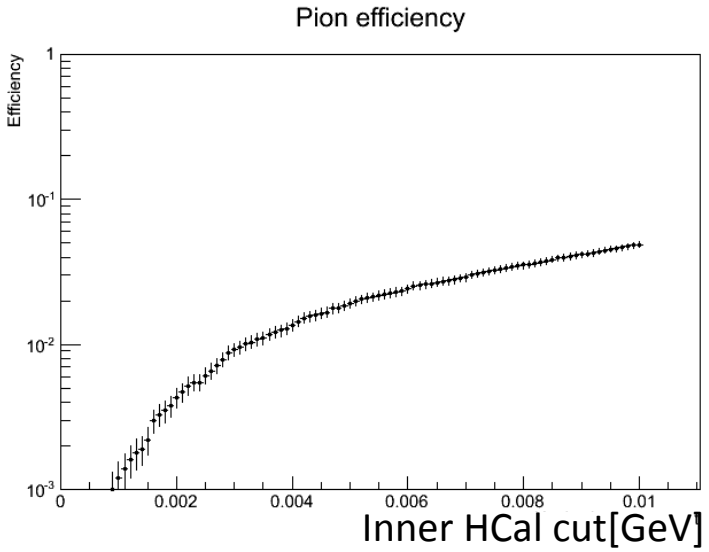
「Simulation」

- 4GeV e^- and π^-,
- Magnetic field off,
- Calculate efficiency with HCal

Inner HCal distribution





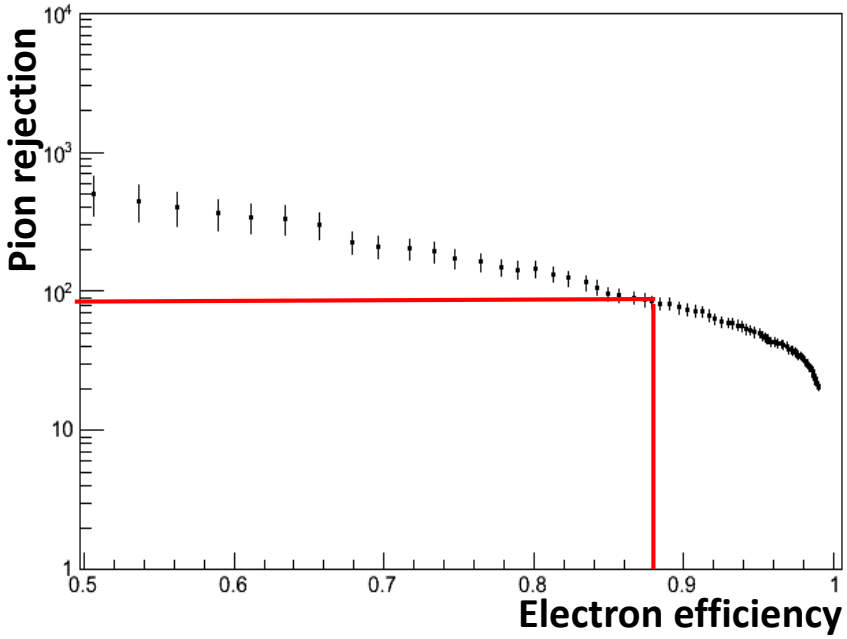


✓ Electron identification with Hcal cut

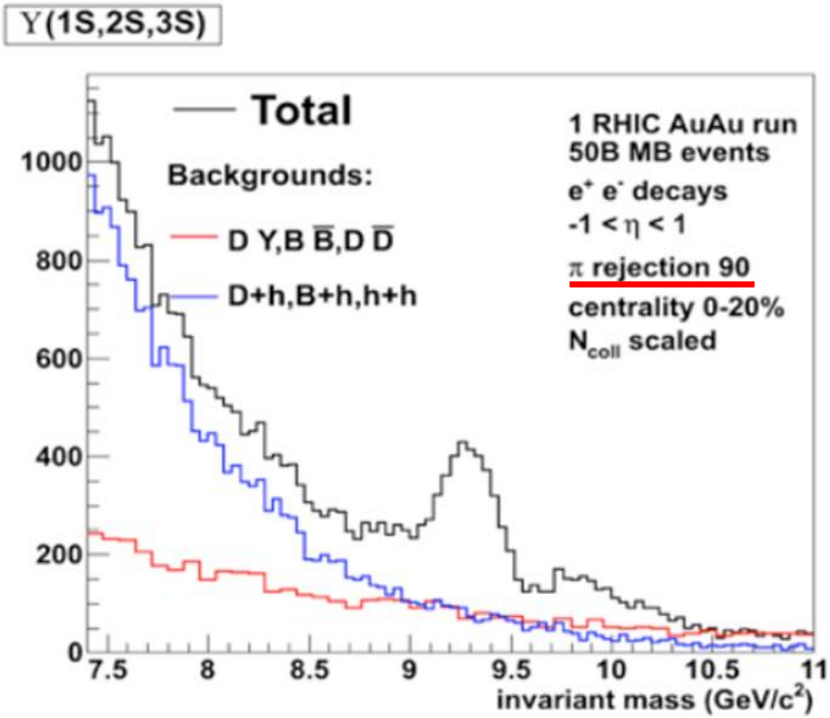
- Pion rejection of 90 with Inner HCal cut: electron eff. 88%

$$\text{Pion rejection} = \frac{Electron\ efficiency}{Pion\ efficiency}$$

Pion rejection with HCal cut



Mass distribution by simulation

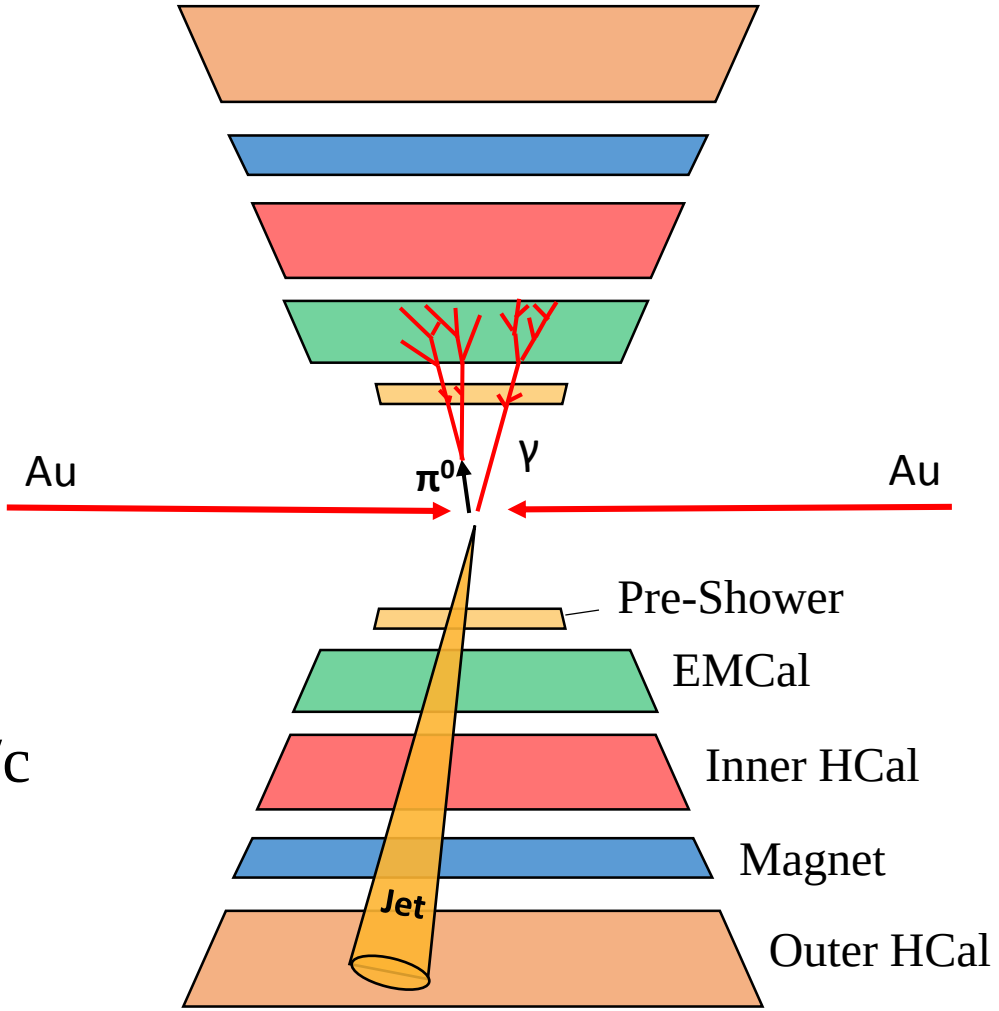


S/B at all states is order 1

✓ Pre-Shower

「Pre-Shower detector」
- Pb convertor + Silicon
- $\Phi \sim 2\pi$, $\eta \pm 0.5$, radius = 90cm

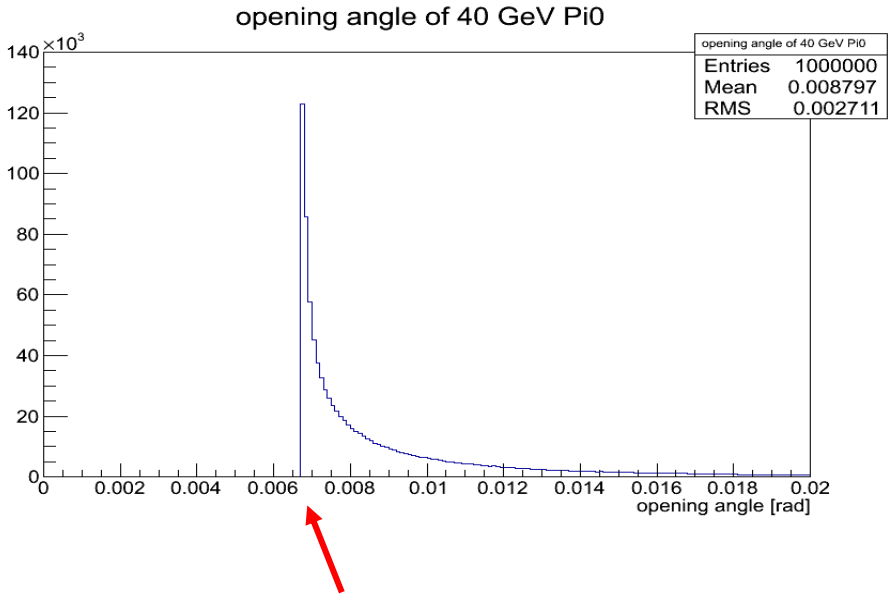
Motivation of Pre-Shower
- γ-jet correlation
  - Distinguish direct photon and 2γ from high p_T π^0
- High p_T suppression
  - High p_T π^0 R_{AA} up to 40 GeV/c
- Upsilon measurement
  - Electron identification



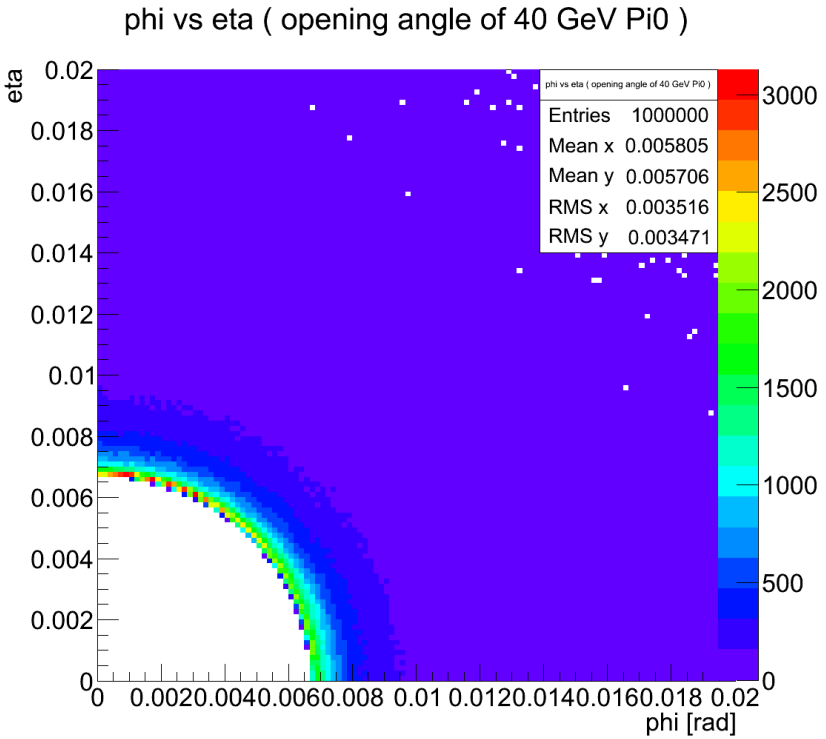
✓ Opening angle of 40GeV/c π^0

「Monte carlo simulation」

- 40 GeV π^0 -> 2γ,
- Calculate Opening angle of 40GeV/c π^0
- Lower limit of 6.7×10^{-3} [rad]
- Decompose opening angle to phi and eta



Lower limit of 40GeV pion opening angle

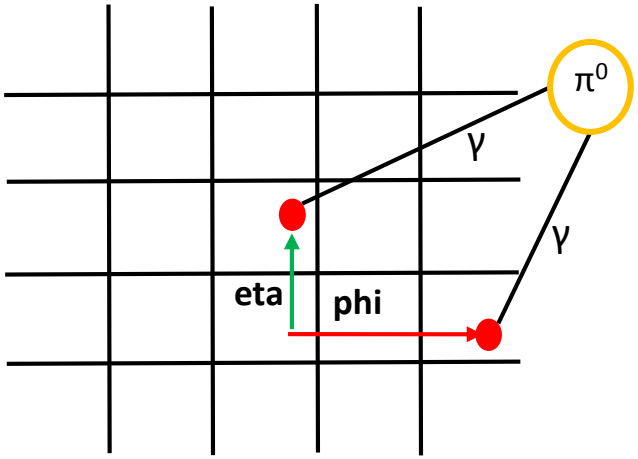


✓ Optimization shape of preshower cell

- Optimize shape and size of cells
- The number of preshower cells is 0.7M (phi × eta = 10^{-5})
- We assume the preshower as <u>perfect detector</u>
- Slime line shape(phi=0.001, eta = 0.01) is the highest efficiency

Detection efficiency

- 2 γ are separated by one cell or more

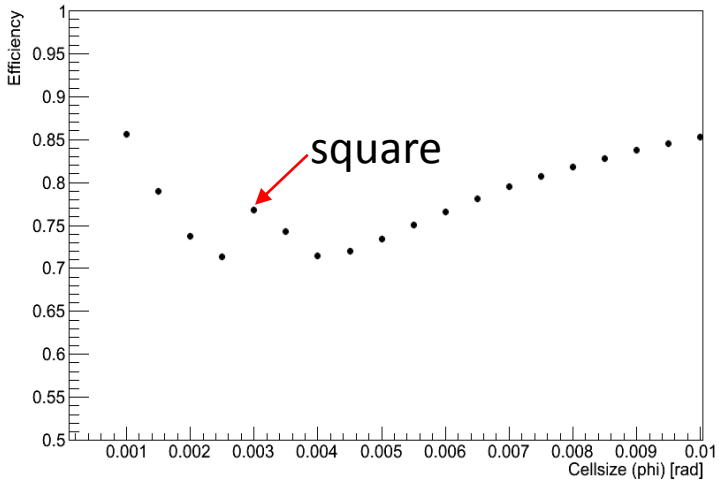


Constant area (phi × eta = 10^{-5})

phi 0.001 -> 0.01

eta 0.01 -> 0.001

Detection efficiency of 40GeV pi0



✓ Hit map at Preshower and EMCal

[Geant4]

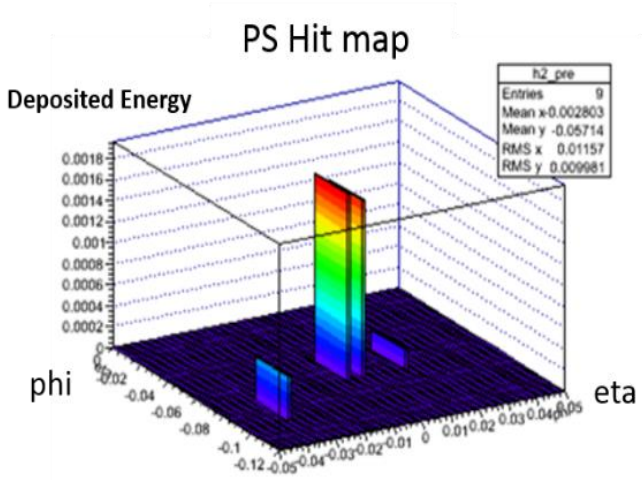
- Pre-Shower and EMCal hit map
- 40GeV pion,

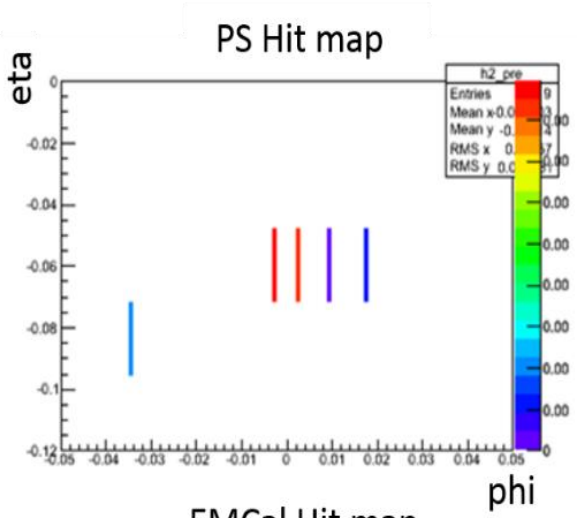
☐ Pre-Shower

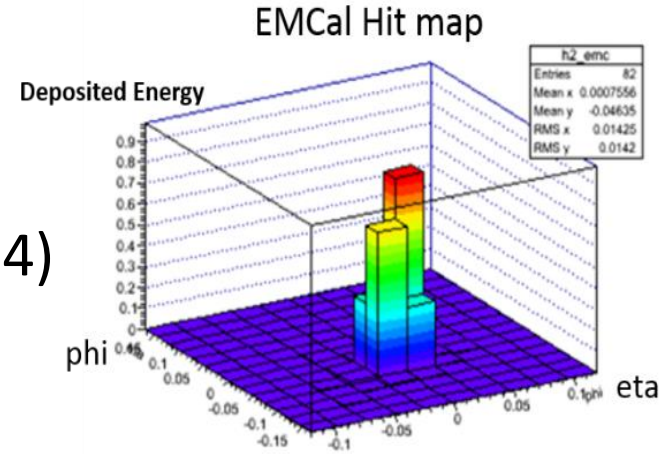
- Size of cell
  (dϕ=0.001,dη=0.01)
- Thickness = $1X_0$
- 2γ are separated

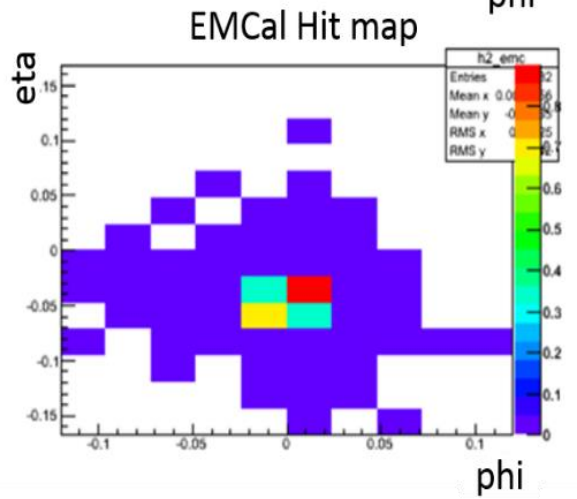
☐ EMCal

- Size of cell
  (dϕ=0.024,dη=0.024)
- Thickness = $18X_0$
- 2γ are merged







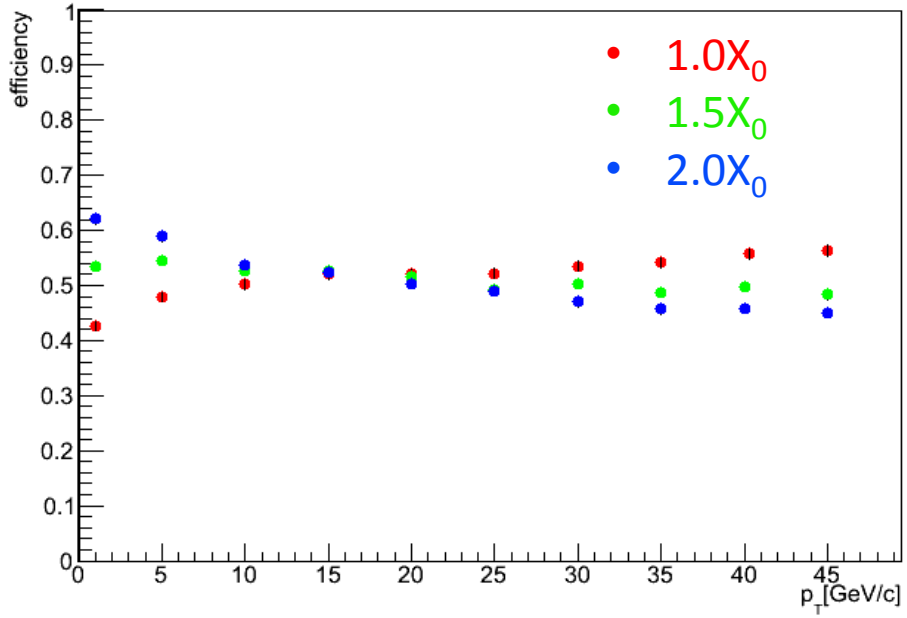


✓ Detection efficiency with Geant4

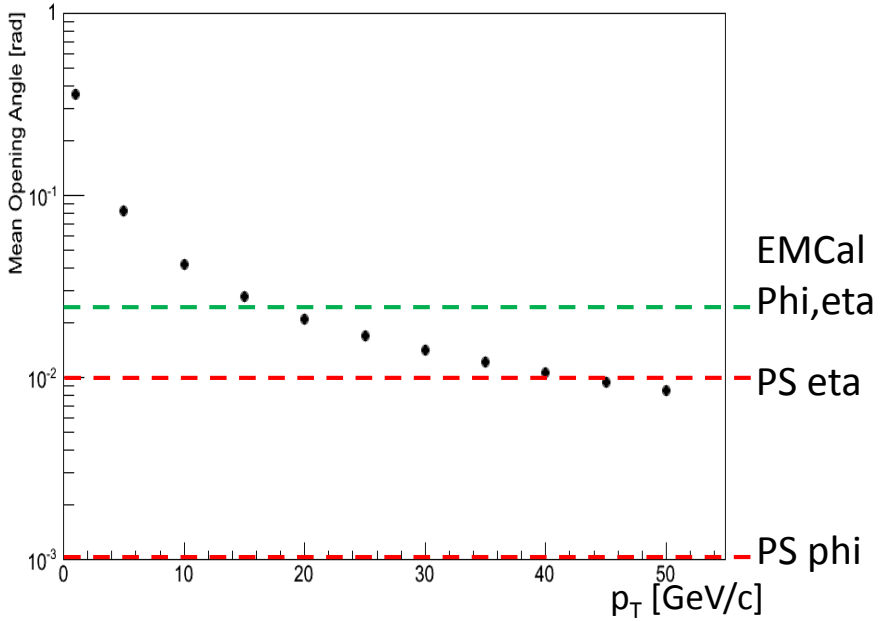
「Geant4」

- Evaluated detection efficiency at slim line shape under realistic condition (phi = 0.001, eta = 0.01)
- Studied dependence of convertor thickness (1.0~2.0X_0)
- In more than 15GeV/c, 1.0 radiation length is higher than other

Detection efficiency of π^0



Average opening angle

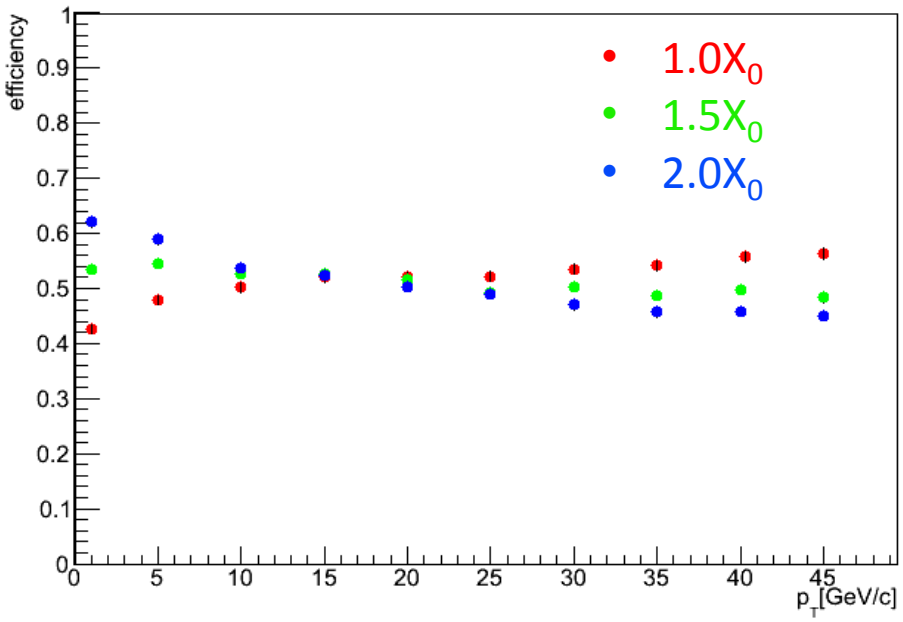


✓ Detection efficiency with Geant4

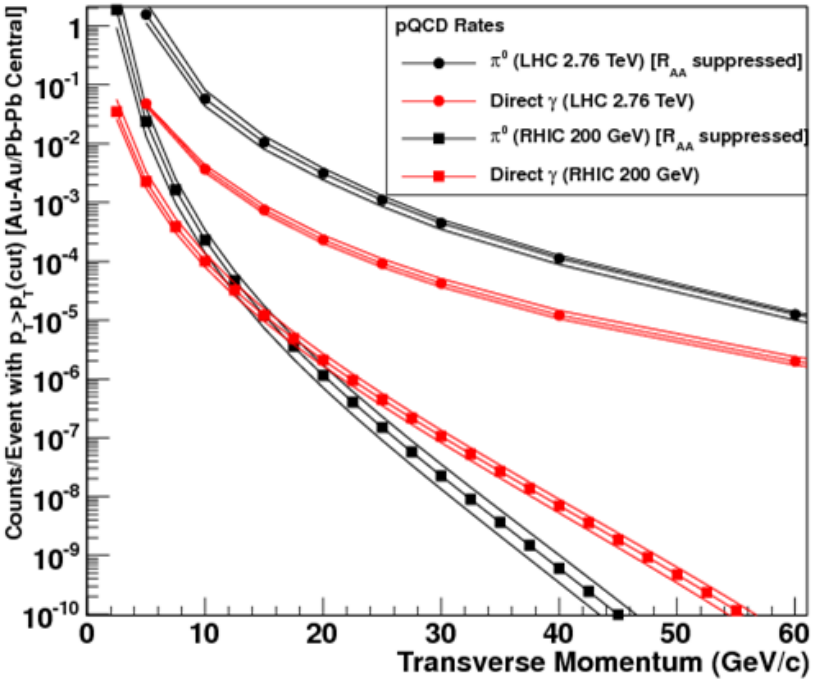
「Geant4」

- Evaluated detection efficiency at slim line shape under realistic condition (phi = 0.001, eta = 0.01)
- Studied dependence of convertor thickness (1.0~2.0X_0)
- In more than 15GeV/c, 1.0 radiation length is higher than other

Detection efficiency of π^0



Count/Event of direct γ and pi0

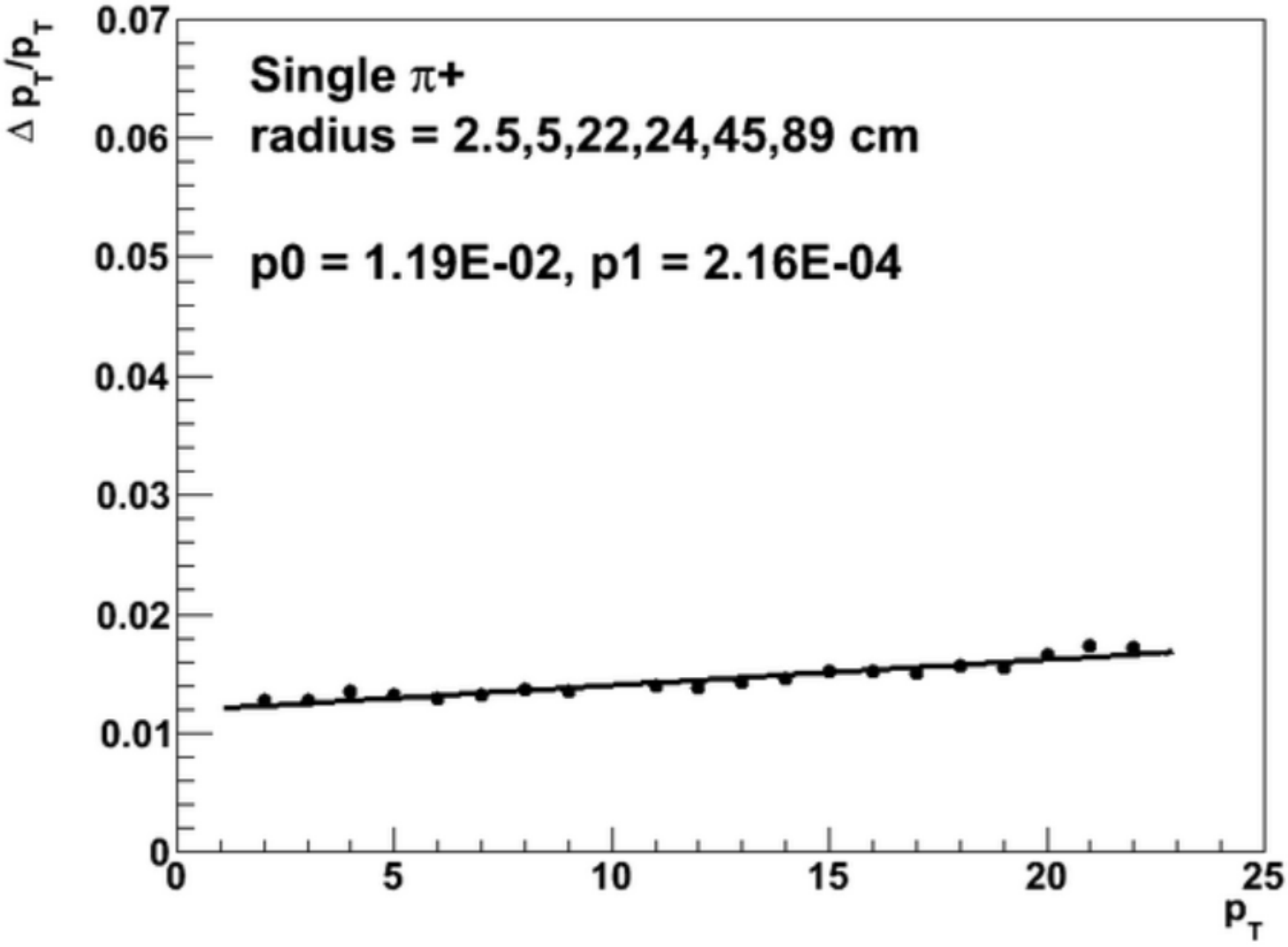


✓ Summary

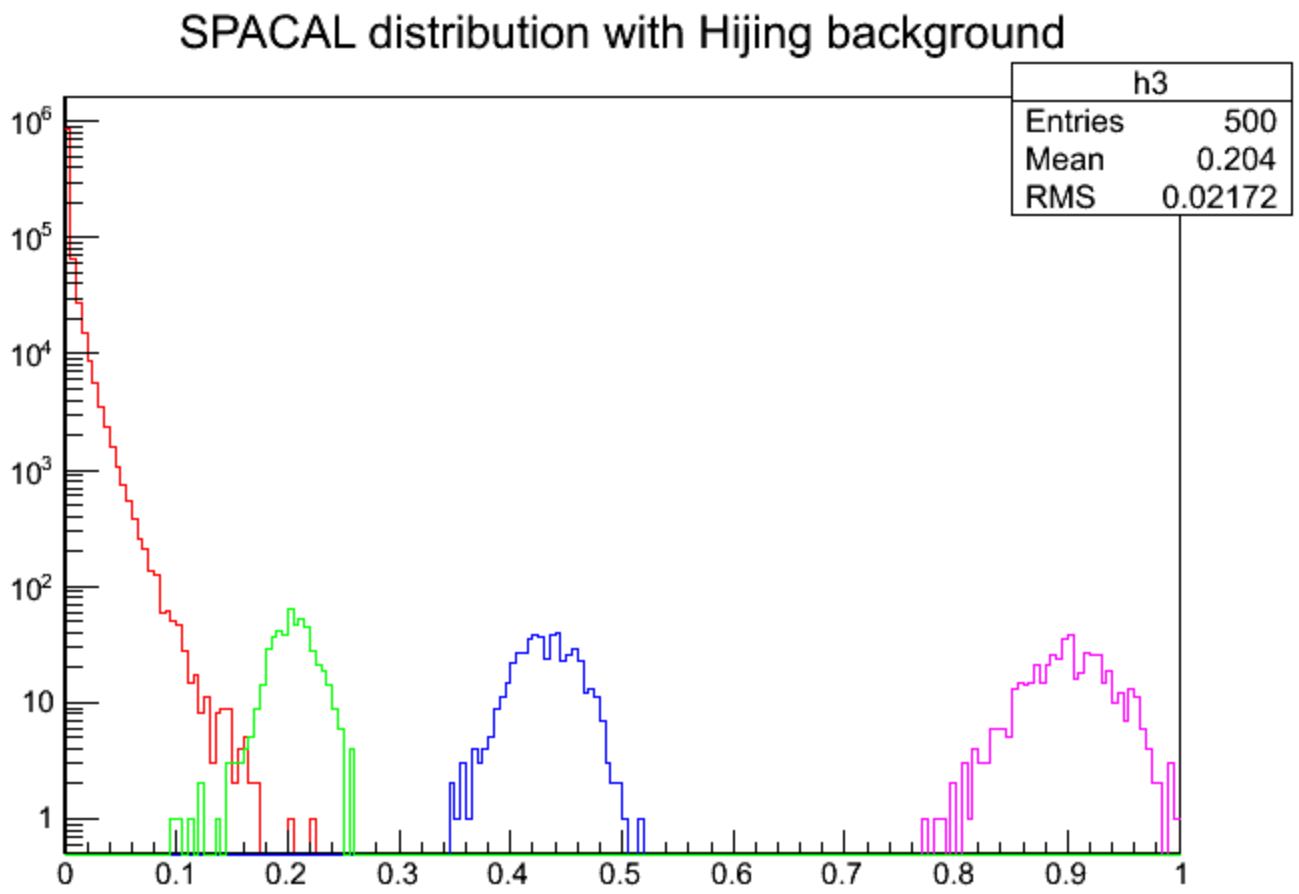
- Pion rejection is 8.0 with E/p cut (electron eff. of 99%)
- Pion rejection is 90 with HCal cut (electron eff. of 90%)
- Upsilon is measurable with 90 pion rejection and 90% efficiency
- Slime line shape is the highest detection efficiency
- Define cell size. phi = 0.001, eta = 0.01
- Preshower convertor thickness of 1 radiation length is the best in case of identifying π^0 in more than 15GeV/c.

✓ Backup

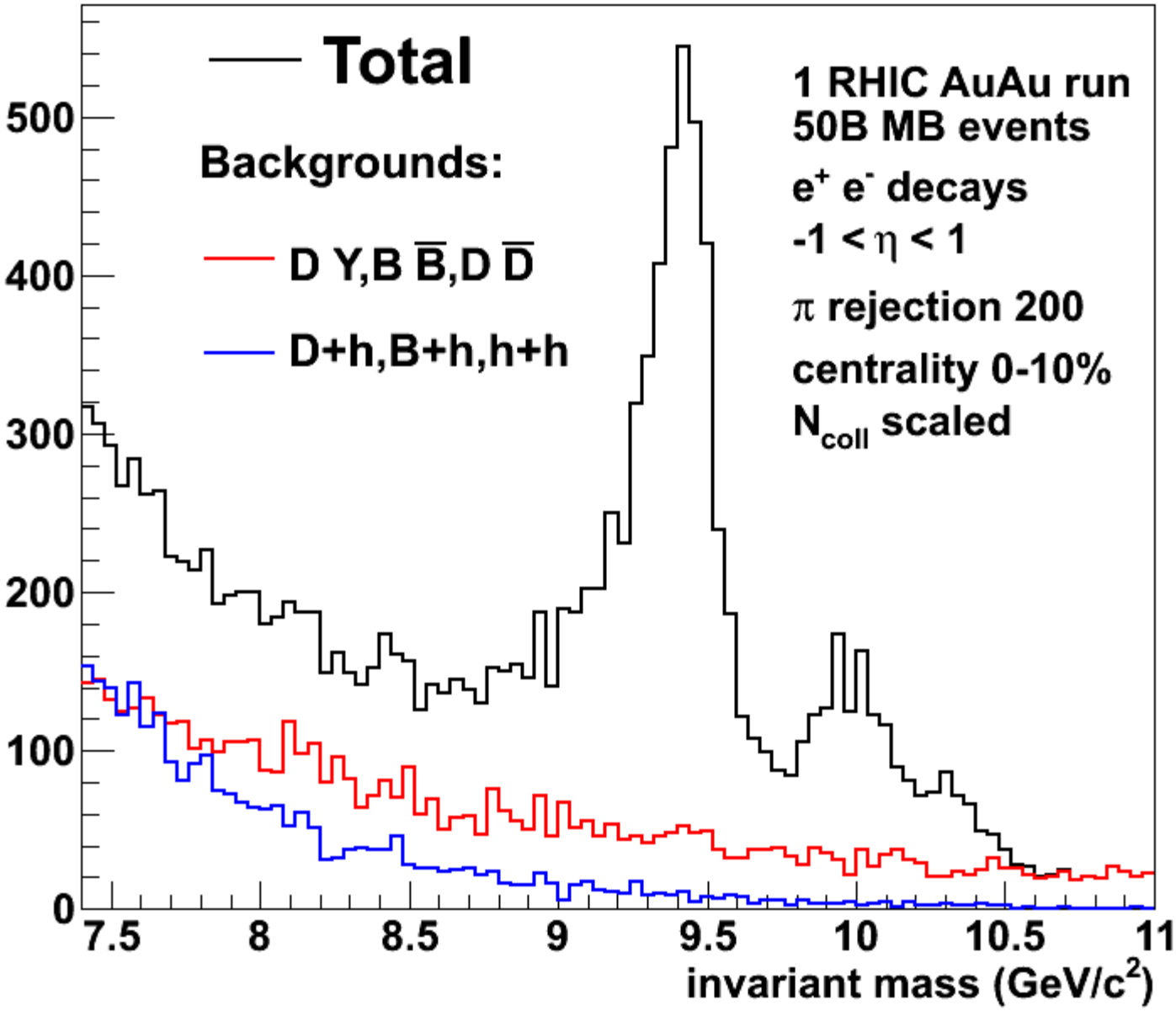
✓ Upsilon mass resolution



✓ Backup

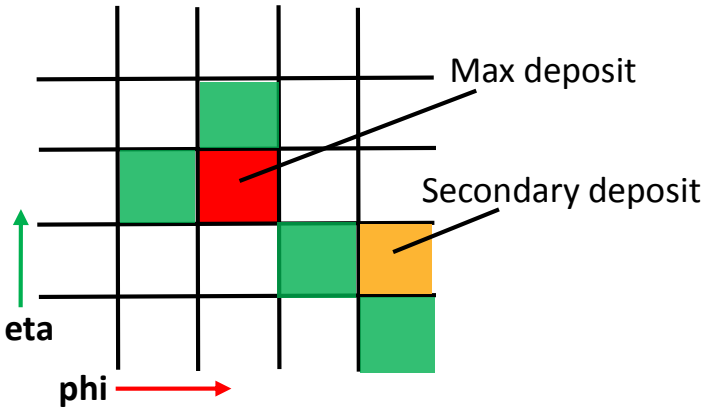

SPACAL distribution with Hijing background
h3
Entries 500
Mean 0.204
RMS 0.02172
10^6
10^5
10^4
10^3
10^2
10
1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

✓ Υ(1S,2S,3S)

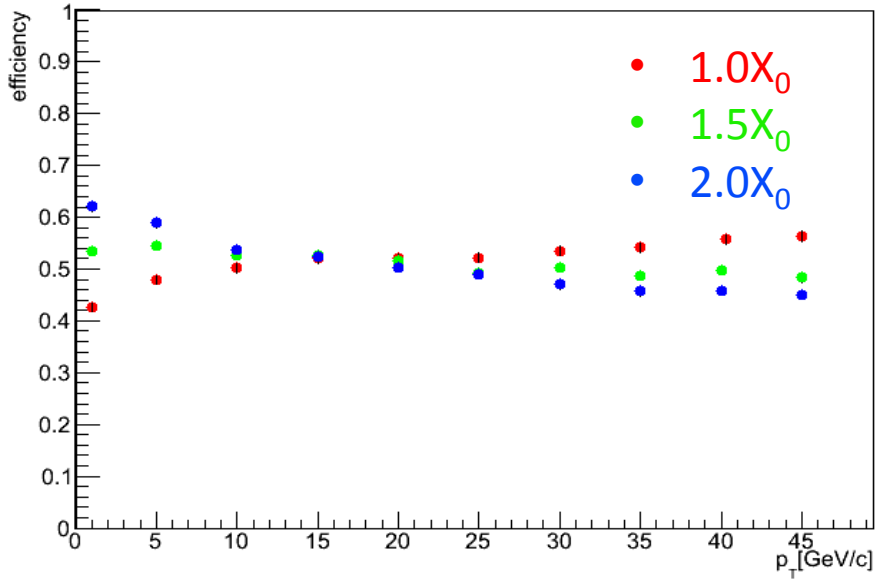

Total
Backgrounds:
D Y,B B̄,D D̄
D+h,B+h,h+h
1 RHIC AuAu run
50B MB events
e+ e- decays
-1 < η < 1
π rejection 200
centrality 0-10%
N_coll scaled
500
400
300
200
100
0
7.5
8
8.5
9
9.5
10
10.5
11
invariant mass (GeV/c²)

✓ Detection efficiency with Geant4

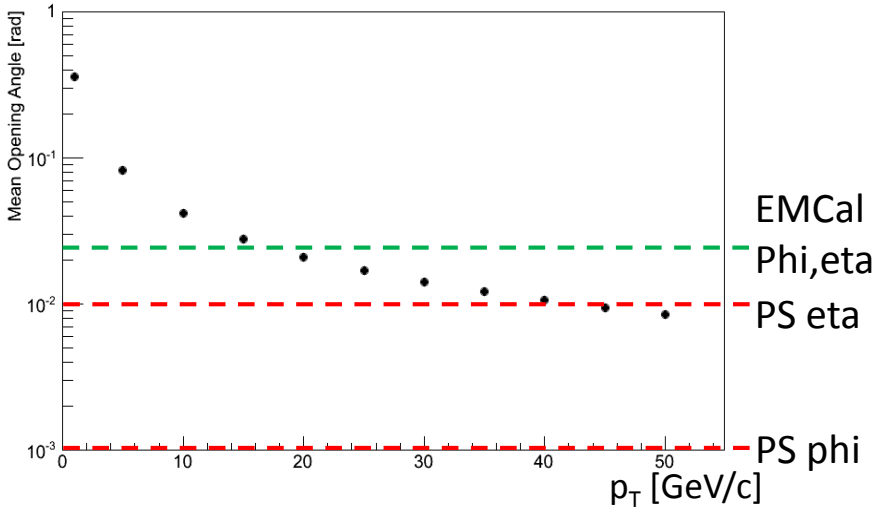
- Evaluated detection efficiency at slim line shape (phi = 0.001, eta = 0.01)
- Studied dependence of convertor thickness
  - 1.0~2.0X_0
- Defined detection efficiency
  - Secondary deposit > Max deposit/3
  - Secondary deposit is away one cell or more from max deposit.



Detection efficiency of π^0

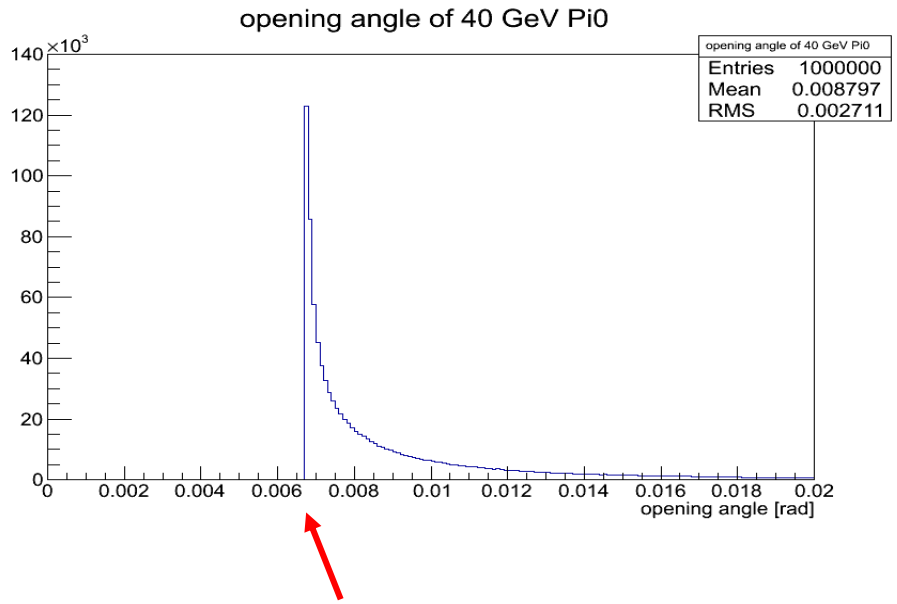


Average opening angle

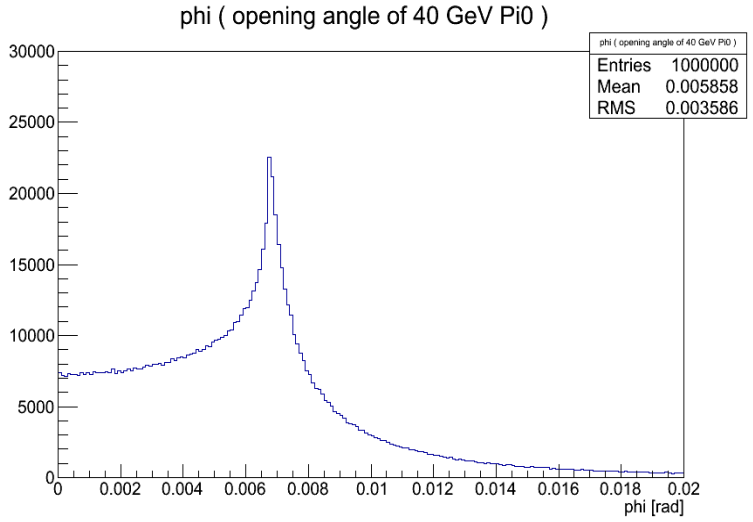


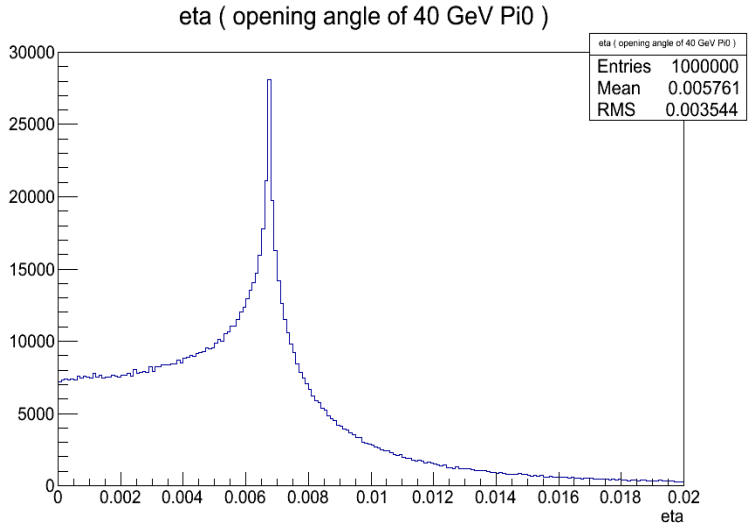
✓ Opening angle of high p_T π^0

- 40 GeV pion -> 2γ,
- Lower limit of 6.7×10^{-3} [rad]
- Decompose opening angle to phi and eta



Lower limit of 40GeV pion opening angle

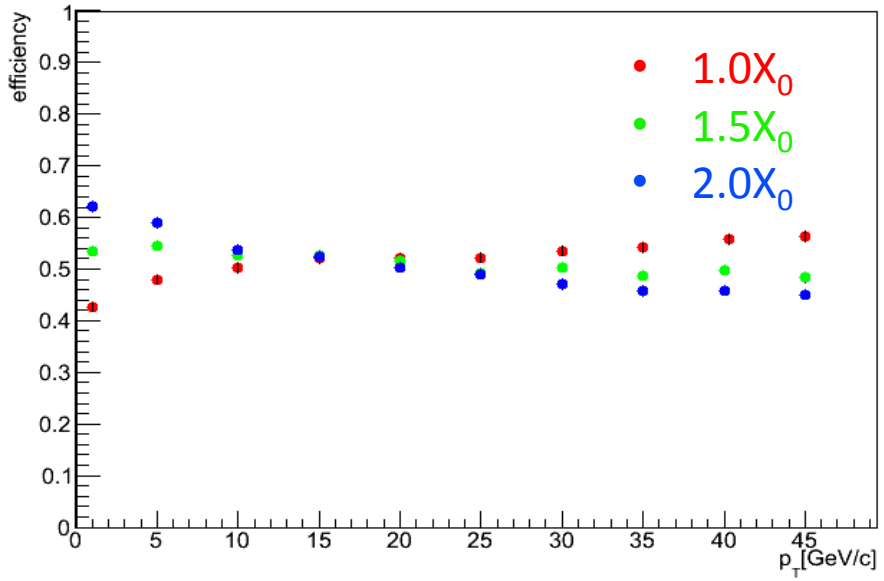




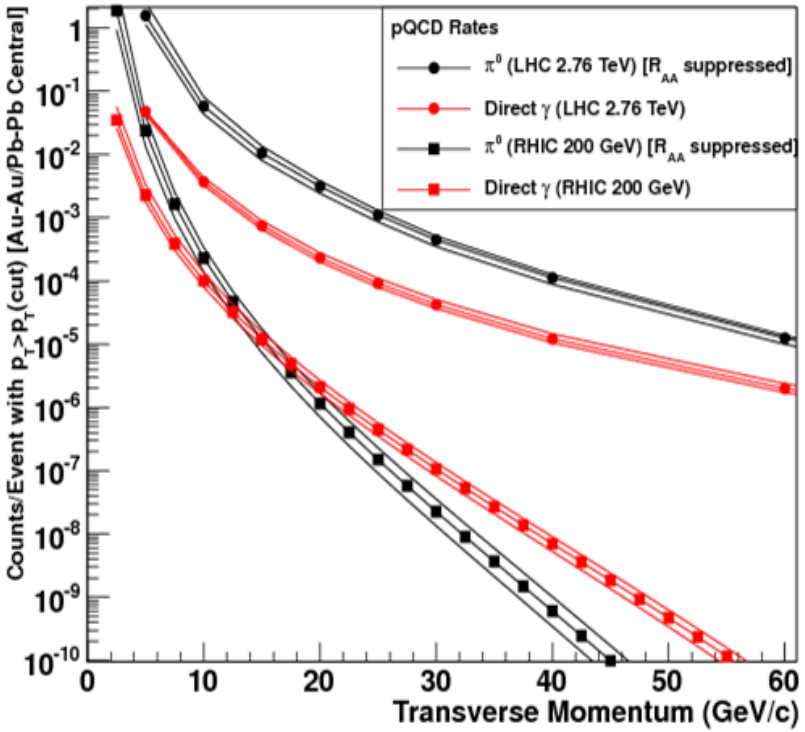
✓ Detection efficiency with Geant4

- Evaluated detection efficiency at slim line shape
  (phi = 0.001, eta = 0.01)
- Studied dependence of convertor thickness
  - 1.0~2.0X_0
- Defined detection efficiency
  - Secondary deposit > Max deposit/3
  - Secondary deposit energy away one cell or more from max deposit.

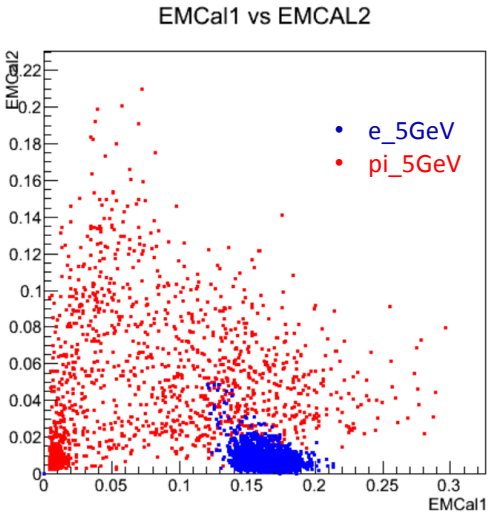
Detection efficiency of π^0

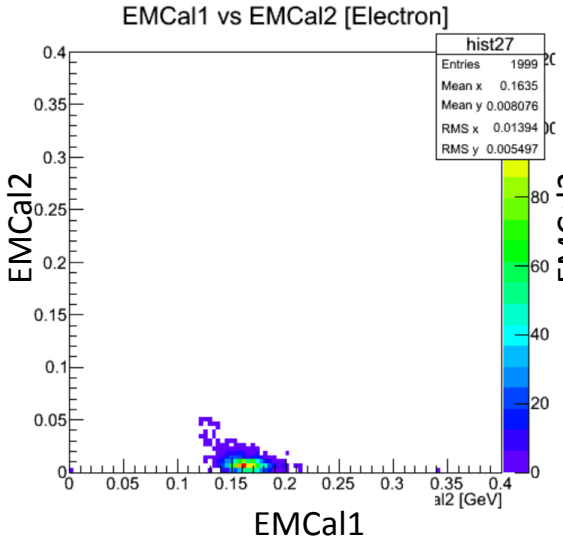


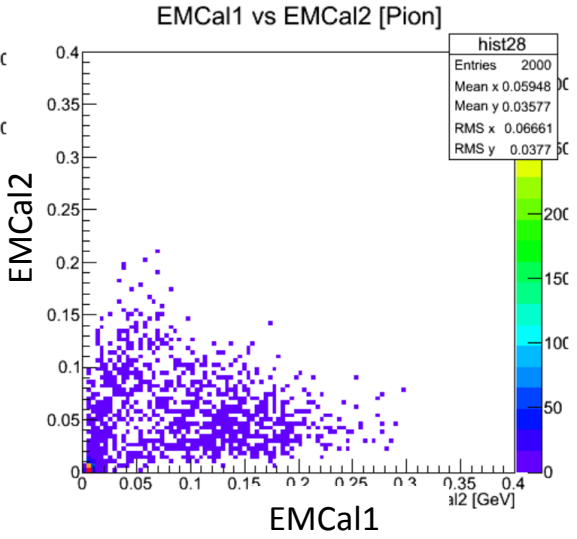
Count/Event of direct γ and pi0



✓EMCal1 vs EMCal2







EMCal1 -> Layer 1~25

EMCal2 -> Layer 26~40